IS 5496 (1993): Guide for preliminary dimensioning and layout of elbow type draft tubes for surface hydroelectric power stations [WRD 15: Hydroelectric Power House Structures]

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IS 5496 : 1993
(Reaffirmed 2003)

भारतीय मानक

पृष्ठीय जल विद्युत पावर स्टेशन के लिए एल्बो किस्म के प्रारूपी नलिकाओं के प्रारम्भिक आयाम और अभिन्यास की मार्गदर्शिका

(पहला पुनरीक्षण)

Indian Standard

GUIDE FOR PRELIMINARY DIMENSIONING AND LAYOUT OF ELBOW TYPE DRAFT TUBES FOR SURFACE HYDROELECTRIC POWER STATIONS

(First Revision)

UDC 627·85 : 621·224-225·14

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NEW DELHI 110002

September 1993 Price Group 2

Hydraulic Power House Structures Sectional Committee, RVD 15

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Hydroelectric Power House Structures Sectional Committee had been approved by the River Valley Division Council.

The draft tube of a reaction turbine is the conduit connecting the exit from the runner to the tail race, thus having the function of utilizing the differential elevation between the runner exit and the tail water level, termed as static suction head, recovering as much as possible of the velocity head in water leaving the runner. Draft tubes may be one of the following types:

a) Straight conical draft tube;

b) Hydraulic cone type draft tube, for example, moody type which may be:

   1) High cone;
   2) low cone; and

c) Elbow type draft tube.

NOTE — The types given at (a) and (b) are normally used for very small units.

This standard is intended for fixing up the preliminary overall dimensions of elbow type draft tubes for the purpose of incorporating them in the project design (layout of the power house) when the design of the draft tube is not available from the manufacturers. It also gives general guidance for the design of the elbow type draft tubes.

This standard was first published in 1969. The present revision has been made in view of the experience gained during the course of these years in use of this standard. The following changes have been incorporated in the first revision:

1) The width of each pier is recommended as 1 000 mm.

2) Draft tube design type 3 has been deleted.

3) Depth of Kaplan & Francis turbine recommended has been increased.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

GUIDE FOR PRELIMINARY DIMENSIONING AND LAYOUT OF ELBOW TYPE DRAFT TUBES FOR SURFACE HYDROELECTRIC POWER STATIONS

(First Revision)

1 SCOPE

This standard covers the criteria for the selection of various dimensions of elbow type draft tubes for hydroelectric power stations.

2 REFERENCES

The Indian Standards listed below are necessary adjuncts to this standard:

IS No.	*Title*
226 : 1985	Structural steel (standard quality) (*fifth revision*)
2062 : 1985	Weldable structural steel (*third revision*)

3 HYDRAULIC DESIGN CRITERIA

3.1 The dimensions of the draft tube depend on the specific speed, size and spacing of the unit and is mainly governed by the diameter of the runner.

3.2 The design should be such that the total losses in the draft tube and exit losses should be minimum possible economically. The deceleration should be gradual and so that transition should be gradual with smooth surfaces.

3.3 One or two intermediate piers in the draft tube leg may be provided to give structural support and also to reduce the span of the draft tube gates which are required for dewatering of the draft tube. Piers should be well streamlined so that they are efficient hydraulically. The number of piers depends upon structural considerations, however, it is recommended that no pier should be provided with span up to 7 m; one pier should be provided for span from 8 m to 15 m and two piers should be provided for span more than 16 m. For spans between 7 m and 8 m and 15 m and 16 m, this choice is left to the discretion of the designer. The minimum width of each pier should be as 1 000 mm sufficient to accommodate the draft tube gate grooves.

3.4 Preliminary design of draft tubes may be made by referring to either of the Fig. 1 and 2 in accordance with the values of *H*, *L* and *B* given in **3.5**, **3.6**, **3.7** and **3.8** respectively.

NOTE — The dimensions given in 3.5, 3.6, 3.7 and 3.8 are only for preliminary design. The final dimensions should, however, be taken as supplied by the turbine manufacturers.

3.5 For the inlet cone of the elbow type draft tubes, the half angle of conicity recommended is 6° to 10°. A bed slope of about one vertical to ten horizontal is recommended. However, a slope of one vertical to six horizontal is the steepest slope which should be permitted.

3.5.1 The outlet end of the draft tube should be so located that it remains submerged under all operating conditions of the unit at least by $V_e^2/2g$ or 30 cm whichever is greater, where V, is the exit velocity and g is the acceleration due to gravity. The slope of excavation connecting the draft tube floor at exit and bottom of the tail race should not be steeper than one vertical to four horizontal.

3.5.2 The height of the draft tube at exit is normally recommended as 0·94 *D* to 1·32 *D* (*D* being the inlet diameter of the runner) depending upon the specific speed of the turbine; the lower value being for lower specific speeds.

3.6 Depth of the draft tube is reckoned from the centre line of the guide apparatus.

3.6.1 For Kaplan turbines normally a depth of 2·3 to 3·0 *D* is recommended depending upon specific speed of the turbine. For Francis turbine a depth of 2·5 to 3·3 *D* is recommended. This may vary to a certain extent depending upon factors enumerated in **3.1**.

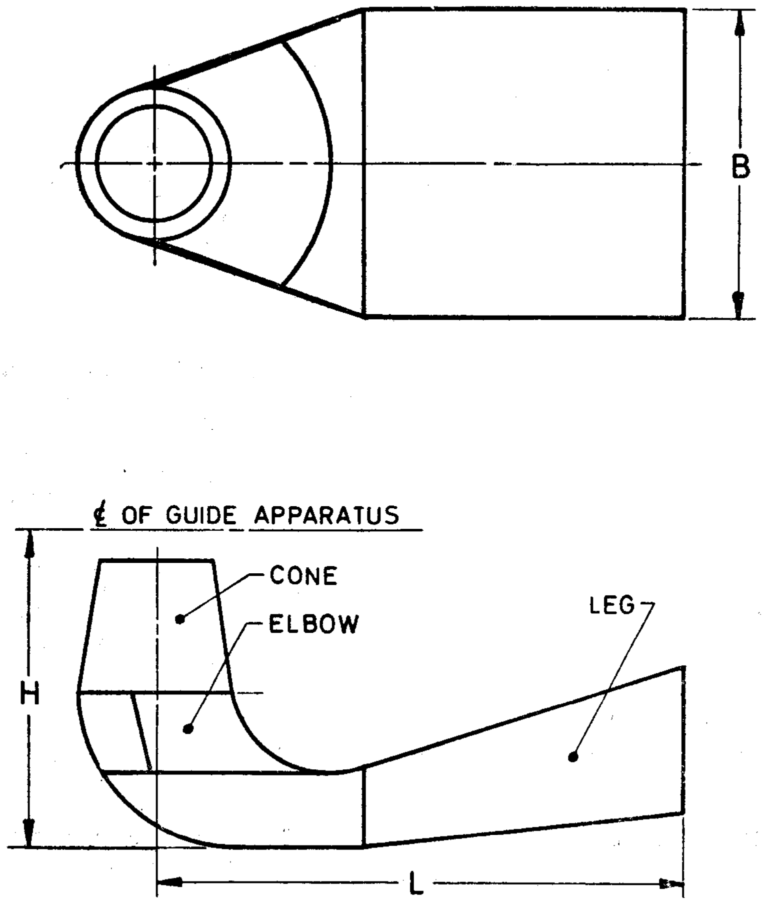
3.7 The length of the draft tube, measured from the turbine axis, is normally recommended as 4 to 5 times the runner inlet diameter.

3.8 The basic width (excluding the pier) of the draft tube exit is normally recommended as 2.6 to 3·3 *D*. In exceptional cases it may be even higher or lower.

3.9 For better block arrangement, draft tubes are sometimes made eccentric with respect to the unit centre line in plan. The value of the eccentricity should be limited so as not to adversely affect the hydraulic characteristics of the turbine.

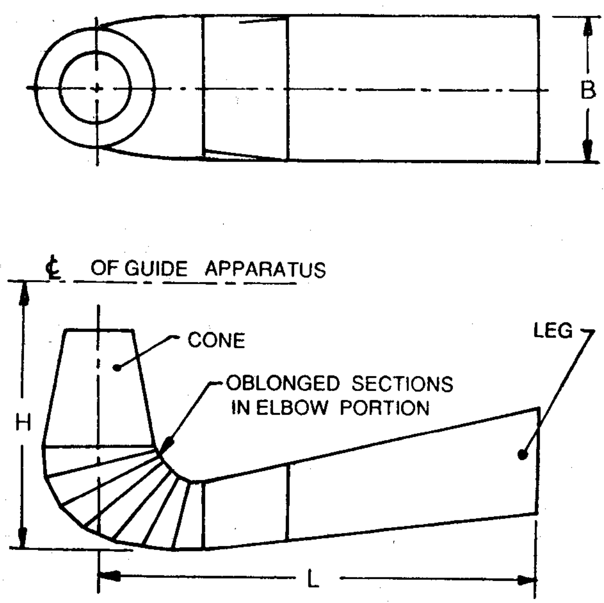
4 MATERIAL

4.1 Draft tubes should be made of R.C.C. of required strength with necessary reinforcement.



H = Depth of the draft tube
L = Length of the draft tube
B = Width of the draft tube

FIG. 1 DRAFT TUBE DESIGN TYPE 1 (FOR HEADS UP TO 200-250 m)



H = Depth of the draft tube
L = Length of the draft tube
B = Width of the draft tube

FIG. 2 DRAFT TUBE DESIGN TYPE 2 (FOR HEADS ABOVE 200-250 m)

4.2 Steel plate liners should be provided in the draft tube to overcome the effects of erosion and pitting due to cavitation, if it exists.

4.2.1 The liner should extend to a point where the concrete can withstand the existing water velocities. This depends on the quality of concrete and its surface smoothness.

4.2.1.1 It is recommended that no liner should be provided for water velocities up to 6 m/s. Besides this consideration of velocity of water in the draft tube, it is recommended that liner should be provided in the cone of the draft tube. However, many times, due to the complicated shape of the elbow a liner may have to be provided in that portion also on the basis of the techno-economic calculations.

NOTE — In certain cases velocities up to 8 m/s have been permitted without the provision of a liner.

5 MODEL TESTING

5.1 The model of the draft tube should be made along with the model of runner and tested along with it under all conditions of working of the machine.

6 ARRANGEMENTS FOR DEPRESSING WATER LEVEL INSIDE DRAFT TUBE

6.1 In case where the generator coupled with the turbine is to be operated as a synchronous condenser, arrangements should be made to depress the water level in the draft tube by means of compressed air. This is accomplished by admitting compressed air to the runner chamber subsequent to the closing of the wicket gates (guide vanes). Compressed air should be admitted through a pipe and an opening check valve should be provided in the air in take pipe. The check valve should be sufficiently air-tight against the pressure in the runner chamber to prevent leakage.

7 ACCESS TO THE DRAFT TUBE

7.1 For facilitating erection and maintenance of the runner and for the upkeep of the draft tube an easy access to the draft tube should be provided. The dimensions of the access should be adequate for a man to get in freely with provision to let down a ladder. The door of the access should be of steel and of enough thickness to withstand the pressures and impact of water. The door should be well fastened with rubber gasket packing all round to ensure water and air tightness. The door should be provided in the vertical portion of the draft tube. These openings should be connected to an access gallery running downstream or upstream or by the side of the unit.

7.1.1 In case where, because of heavy silt load in the water passing through the turbine, frequent repair/change of runner is envisaged, arrangement for removal of the runner through an opening provided in the draft-tube cone, should be made. The opening should be adequate enough to pass the runner through it. A steel door should be provided at the opening. The door should be well fastened with rubber gaskets all around to ensure air and water tightness. The openings provided for runner removal should be aproachable through access galleries of adequate size. These galleries may be provided with rails to take out the runners on specially designed trolleys.

8 DRAFT TUBE GATES

Bulk head gates should be provided to close the draft tube against tailwater pressure during the maintenance period. The gate should be designed to carry the maximum tailwater pressure conditions. Suitable gantry with necessary operating platform should be provided for operation of the gates.

9 DRAINAGE BOX FOR DEWATERING DRAFT TUBE

To facilitate dewatering of draft tube a drainage box should be fixed at the lowest point of the draft tube. The drainage box should then be connected to the power house sump directly or through a pipe system passing through a drainage gallery.

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Doc : No. RVD 15 (28)

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Printed at Printrade, New Delhi, India

AMENDMENT NO. 1 MARCH 2001
TO
IS 5496 : 1993 GUIDE FOR PRELIMINARY DIMENSIONING AND LAYOUT OF ELBOW TYPE DRAFT TUBES FOR SURFACE HYDROELECTRIC POWER STATIONS

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(*Page* 1, *clause* 2, *References*) — Substitute the following for the existing matter:

The Indian Standard IS 2062 : 1992 'Steel for General structural purpose' (Superseding IS 226) is a necessary adjunct to this standard.

(WRD 15)

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